

RESEARCH AND DEVELOPMENT BRANCH

DEPARTMENT OF NATIONAL DEFENCE CANADA

DEFENCE RESEARCH ESTABLISHMENT OTTAWA

TECHNICAL NOTE NO. 86-10"

. SEASAT SQUATOR CROSSING PROGRAM.

| 8 G | Young and O.L. Duswimon Defence Electronics Division

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ABSTRACT

A programable pother calculator to used to extrapolate the SEASAT orbit from the equator crossing to the position at which the equitoric aperture roder tanges a given target. The program products the coordinates of the actellite at tange time, the Azimuth direction of the tange at the target, and the time clapsed between equator crossing and imaging. Program productions are tempored with measured SEASAT data from the definition accuracy of time.

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Ce tapport d'etti le lagistel d'une colculateur de porte programmile pour l'entrapolation de l'orbite du socialité SLABAT à partir de sa traverule sur-dessus de l'équateur jusqu'à sa position largeur le rador à antonne synéthétique tauge une tible. Ce programme persut de prévoir les coordannées de satellite au autont de la production de l'image, la direction assauthale de l'image au point de la cible et le temps évoulé entre le pausage à l'équateur et celui de la production de l'image. Con prédictions sont comparées avec les dessées accurées de SLABAT contabues dans les fichiers à bandes augustique des dessées d'attitudes et d'arbites.

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1.0 INTRODUCTION

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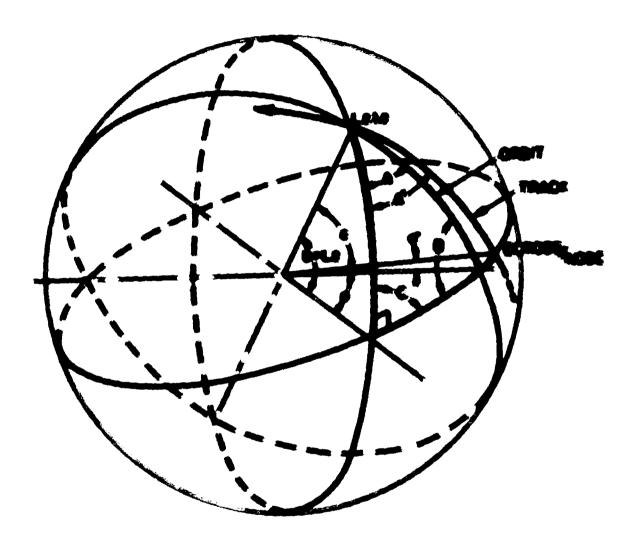
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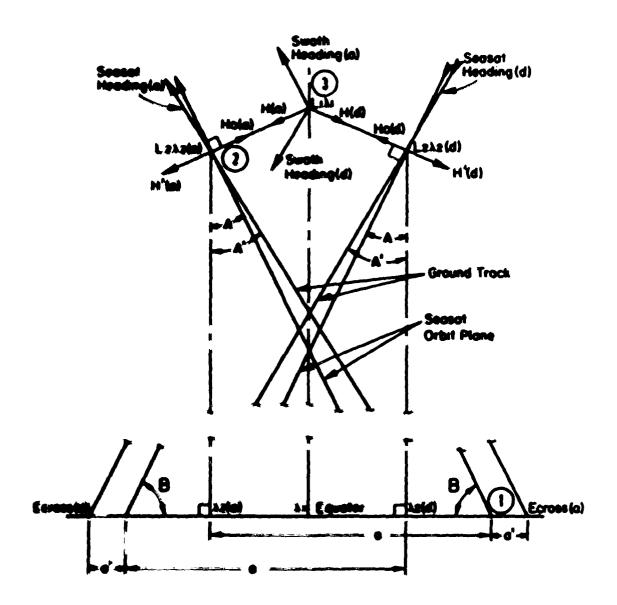
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TABLE III
PROGRAM LISTING, ASCENDING (a)

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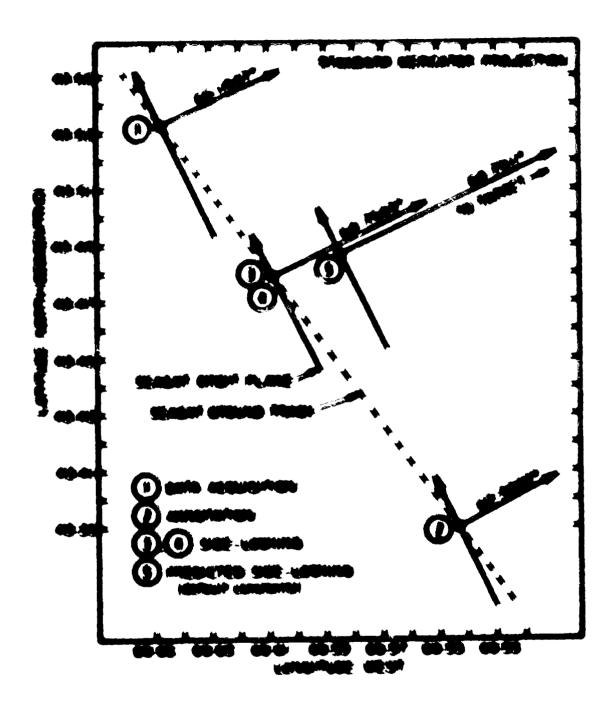
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TABLE IX
SEASAT SAR IMAGING PARAMETERS

	3 A/O Tape	5 нр - 67	
	(side-looking	(default	2.55
Parameter	time)	constants)	Diff.
Latitude L ₁ N	44.4566	44.4566	
Longitude λ_1 W	63.5833	63.5833	
E CERSO /Node E	314.5999	314.5999	-
Node Time (CMT)	13:33:30.55	13:33:30.55	-
Latitude L ₂ N	43.4784	43.4873	+0.0089
Longitude λ_2 V	66.6077	66.5844	-0.0233
'image' Time (GAT)	13:46:28.42	13:46:28.90	+0.48 sec
t. (min)	12.9645	12.9725	+0.0080 min
Clock Angle	90.0000	90.0000	-
South Heading	334.2897	334.3085	+0.0188
SEASA? Weading	332.1897	332.2245	+0.0348
Distance to Target (Km)	265.1617	263.0470	-2.1147
Heading to Target	64.7543	64.7911	+0.0368
evett/Equator Intersect W	48.6317	48.6337	+0.0020
Cybit Inclination	108.0281	108.0000	-0.0281
orbit Period (min)	100.6889	100.7500	+0.0611

change in image time is 1.9833 seconds.

The effect of satellite attitude on annotation time can be shown by expressing the pitch and yaw angles (-0.3587° and 0.3818° respectively at data acquisition time) as a squint angle in the slant range plane. Pitch and yaw normally deviate from the design specifications by less than 0.5°. Small angle approximation is therefore acceptable. Let the SEASAT SAR beam shift ϕs radians from the side-looking position in the slant range plane. The velocity component in the slant range direction due to ϕs is $v_s = \phi s V$ and the corresponding shift of the image in the cross range direction is, from equation (21) $\Delta X = \phi s R$. The change in time is $\Delta T = \phi s R/V$. Note that the image shift ΔX is equal in magnitude but opposite in direction to the extra distance the satellite travels beyond the side-looking position to acquire the radar data in the squint mode. In other words, the annotation time on the image will always be the side-looking time, to the small angle approximation, independent of the radar squint angle if corrections for earth rotation and precession have been applied.

The image shift Δx from a squint angle of 0.008030 radians at the data acquisition position is 6.8099 km. The annotation time due to misalignment alone would be 1.0284 seconds earlier. These values are in good agreement with the great circle distance between the satellite nadir positions in data sets 1 and 3 of 6.8120 km, and the time difference of 1.0053 seconds between the data acquisition time and the side-looking time.

The annotation time in the Halifax frame from Rev. No. 1238 correlated by MDA (MacDonald Dettwiler and Associates) is about 2.66 seconds earlier than the acquisition time [4]. Interpolation from the Halifax frame yields an annotation time for the Halifax Citadel of 13:46:26.78 and the data acquisition time, 2.66 seconds later, of 13:46:29.44 GMT. This value of the data acquisition time is in good agreement with that in data set 1, 13:36:29.43, calculated from the A/O tape. However the annotation time is 0.33 seconds later than would be expected from the sum of the time diplacements from radar squint and earth rotation, 2.99 seconds. The reason for this difference is not known but is assumed to result from the approximations used in calculating the slant range velocity. The MDA annotation time was used to extract data set 2 in Table VII from the A/O tape and the coordinates for point 2 in Figure 3.

5.5 Discussion

The SEASAT ground track shown by the dotted line in Figure 3 represents the attitude - orbit tape data to within 0.002°, the error ascribed to the linear interpolation between orbit entries. Satellite positions along the ground track are less accurate and the data acquisition and side-looking positions, 1 and 3 respectively, depend on the unknown accuracy of the precession correction.

The attitude of the satellite is apparently not predictable and no attempt was made to incorporate an equivalent yaw correction into the calculator

program.

Nominal beamwidth of the SEASAT SAR was 1.25° and the equivalent yaw at image time was about 1.4648°. Therefore, it is clear that the target could not have been illuminated from the side-looking or annotation positions at 2 and 3.

6.0 CONCLUSIONS

- 1. A program for the HP-67 programmable pocket calculator to extrapolate the SEASAT ground track up to one quarter of a revolution beyond the node has been developed and tested. It was shown that SEASAT orbit parameters which were measured during the satellite's lifetime can be fitted by the program using three constants.
- 2. Using the prelaunch design parameters as the default constants, the calculator program predicts SEASAT SAR imaging parameters which fall well within the limits imposed by the normal, but unpredictable, attitude variations. These limits introduce an uncertainty of a few seconds in the data acquisition time and up to a tenth of a degree uncertaintly in the satellite position coordinates. When accurate data acquisition times are required, the program can provide information to help aim a radar detector at the passing satellite.

7.0 REFERENCES

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- 4. Fielden, R.L., <u>MacDonald</u>, <u>Dettwiler and Associates</u>, Private Communication, April 15, 1980.

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SEASAT SATELLITE

SYNTHETIC APERTURE RADAR

HP-67 PROCRAM

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